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Removal of Mercury(II) from Wastewater by Adsorbents from Agricultural Wastes- A Review

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ABSTRACT

Treatment of wastewater from industries is necessary to decrease water pollution, to promote human health, to protect aquatic life and to achieve sustainability of water resources. Mercury is highly toxic even in low concentrations in wastewater. The review presented here focus on the various adsorbents from agricultural wastes used for the removal of mercury by adsorption from wastewater.

Keywords: Mercury, Adsorption, Adsorbents, wastewater

INTRODUCTION

Industries such as plastic industries, oil refineries, pulp industries, cement industries are source of mercury in the environment[1].Nervous system, gastrointestinal and renal systems are adversely affected by the ingestion of mercury –contaminated water, in which mercury combines with the thiol residues present in the proteins of the human body and impairs.[2].The maximum allowable concentration of Hg(II) ion by world health organization (WHO) in wastewater discharge and potable water is 5 and 1 µg/L, respectively[3]. High toxic potency of mercury has necessitated the global need for the removal of Hg(II) fromwastewaters before its discharge in aquatic environment. Conventional methods for the removal ofHg(II) from wastewater include sulphide precipitation, ion exchange, alum and iron coagulation,and adsorption on activated carbon[4]. Adsorption is one of standard procedures in wastewater treatment due to the simplicity of design and smooth operation. Various commercial adsorbents have been used to remove heavy metals from water and wastewater like activated carbons, silica gel, zeolites. However, the use of these adsorbents is limited due to their higher cost. On the other hand, many low-cost adsorbents from agricultural wastes have been utilized to remove heavy metals from wastewater[5]. In this review various adsorbents from agricultural wastes used for the remediation of Hg(II) from wastewater has been presented.

ADSORBENTS FROM AGRICULTURAL WASTES

2.1 Sugarcane Bagasse

Giraldo et al investigated the adsorbent prepared from sugarcane bagasse modified with thermal treatment and chemical activation through activating agents ($ZnCl_2$ and H_3PO_4) and used to remove mercury Hg(II) from aqueous solutions. The maximum adsorption capabilities in this study exceeded 11.47 mg g^{-1}. [6]

2.2 Pistachio wood waste

Seyed-Ali Sajjadi et al used Ammonium nitrate (NH_4NO_3) as a novel activating reagent to prepare a surface-engineered activated carbon derived from pistachio wood wastes. The batch experiments indicated that the adsorption process of Hg(II) was strongly dependent on the solution pH and reached fast equilibrium at approximately 30 min. Pistachio wood activated carbon (202 mg/g) exhibited a significantly higher maximum adsorption capacity than commercial activated carbon (66.5 mg/g). [7]

2.3 Raw rice husk

Rocha et al studied the efficiency of a local and highly available agricultural waste, the raw rice husk, to remove mercury(Hg) from synthetic and natural waters. Different operating conditions were tested, including initial pH, ionic strength, the presence of co-ions (cadmium) and organic matter. The removal efficiency ranged between 82% and 94% and between 90% and 96% for an initial Hg^{2+} concentration of 0.05 mg L^{-1} and 0.50 mg L^{-1}, respectively[8]

2.4 Corn cob

Yuyingnan Liu et al evaluated corn cob as raw material and modified methods employing KOH and $KMnO_4$ were used to prepare activated carbon with high adsorption capacity for mercury ions. When modified with KOH, the optimal adsorption time was 120 min, the optimum pH was 4; when modified with $KMnO_4$, the optimal adsorption time was 60 min, the optimal pH was 3, and the optimal amount of adsorbent and the initial concentration were both

0.40 g/L and 100 mg/L under both modified conditions.The maximum adsorption capacity are 184.76 mg/g and 222.22 mg/g, respectively. [9]

2.5 Garlic scapes

Gour et al prepared finely powdered garlic scapes as bio-adsorbents for mercury removal from simulated wastewater. Batch studies were carried out using AAS(Atomic Adsorption Spectroscopy) by varying contact time, adsorbent dose, temperature and pH. Optimum results were obtained at 10 pH when the adsorbent dose was 50 mg for 45 minutes of contact time at 100ºC. The adsorption efficiency of the prepared biosorbent at optimum conditions was found to be 45–77%.[10]

2.6 Hass avocado seed

Castro-Suarez et al utilized activated carbon from Hass avocado seed to study the removal of mercury from industrial wastewater. The seed was carbonized to obtain activated carbon. Orthophosphoric acid at 21% w/v was used as an activating agent. The Hg^{2+} concentration was determined by atomic absorption spectroscopy. The conditions of the experiments were 50 mL of industrial wastewater at room temperature, pH 6.0, initial concentration of mercury 0.036 mgL^{-1} and 0.2 gL^{-1} of adsorbent material. The average removal efficiency of activated carbon for Hg^{2+} was 84% and an equilibrium concentration of 0.006 mgL^{-1} after 60 minutes.[11]

2.7 Mango Seed

Oscar D. Caicedo Salcedo et al carried out a study of mercury Hg(II) adsorption from aqueous solution on functionalized activated carbon. The activated carbons were prepared by chemical activation of a mango seed with solutions of $CaCl_2$ and H_2SO_4 at different concentrations.The carbonaceous materials were functionalized with Na_2S, to increase the sulfur content in the carbonaceous matrix and its affinity to mercury. It was evidenced that the functionalization process generated an increase in the mercury [Hg(II)] adsorption capacity between 21 and 49% compared to those of the nonfunctionalized materials, reaching a maximum adsorption capacity of 85.6 $mgHg^{2+}g^{-1}$[12]

2.8 Banana Peel

Elaine Fabre et al assessed the use of banana peels as biosorbent for mercury sorption from different aqueous solutions. The impact of the operating conditions, such as biosorbent dosage, contact time and ionic strength was evaluated for realistic initial Hg(II) concentrations of 50 μg dm^{-3}.The equilibrium study showed that Freundlich isotherm provided the best fit to the experimental results ($R^2 = 0.991$),and the sorption capacity of banana peels obtained from Langmuir isotherm was 0.75 mg g^{-1}. [13]

2.9 Pachira aquatica Aubl fruit

Santana et al investigated powders obtained from the peel of the fruit of Pachira aquatica Aubl, in its in natura and/or acidified form, as an adsorbent for the removal of mercury ions in aqueous solution. The adsorption process was evaluated using cold-vapor atomic fluorescence spectrometry and cold-vapor atomic absorption spectrometry. Three isotherm models were employed. The adsorption isotherm model, Langmuir-Freundlich, best represented the adsorption process, and the maximum adsorption capacity was predicted to be 0.71 and 0.58 mg $g^{(-1)}$ at 25 °C in nature and acidified, respectively. Adsorption efficiencies were further tested on real aqueous wastewater samples, and removal of Hg(II) was recorded as 69.6 % for biomass acidified and 76.3 % for biomass in nature.[14]

2.10 Fir Wood saw dust

Fatemeh Kazemi et al producedthe thiol-incorporated activated carbon from fir wood sawdust by treating it chemically with phosphoric acid at five different impregnation ratios and used as adsorbent for Hg^{2+} ion in batch and fixed bed systems. The effects of various parameters such as contact time, adsorbent dose, pH and initial Hg^{2+} concentration for the removal of Hg^{2+} were studied in a batch process. The Hg^{2+} ion removal efficiency increased by increasing the adsorbent dosage from 0.25 to 2 g/L and the pH from 2 to 8. The equilibrium data fitted to the Freundlich, Langmuir and Redlich–Peterson isotherms, but gave a better fit to the Redlich–Peterson model[15]

2.11 Indian Almond fruit shell

Stephen Inbaraj and Sulochana derived a carbonaceous sorbent from the fruit shell of Indian almond (Terminalia catappa) by sulfuric acid treatment for the removal of mercury(II) from aqueous solution. Maximum uptake occured in the pH range of 5–6. The Langmuir and Redlich–Peterson isotherm models defined the equilibrium data precisely compared to Freundlich model and the monolayer sorption capacity obtained was 94.43 mg/g. An optimum carbon dose of 4 g/l was required for the maximum uptake of Hg(II) from 30 mg/l [16]

2.12 Citrus fruit peels

Tushar J. Sahetya et al investigated adsorption of mercury using citrus fruit peels waste from Phyllanthus emblica (Indian gooseberry/amla), Citrus sinensis (orange), Mangifera indica (raw mango) and Citrus limetta (sweetlime). The citrus peels were naturally shade dried, powdered to an average particle diameterof 150–200 μ and usedwithout any

chemical modification. The impact of solution pH,Hg(II) ion concentration and initial Hg(II) concentration was evaluated in batch adsorptionprocess. The order of Hg(II) adsorption was found to be as: P. emblica > C. sinensis >C. limetta > M. indica. Langmuir and Freundlich isotherm describes the equilibriumadsorption condition.citrus peels showed an effective adsorption of 80% atpH 4.

RESULT

In this paper different adsorbents from agricultural wastes utilised for removing Hg(II) from wastewater has been reviewed. It could be implied that various adsorbents can be used efficiently as alternatives to high cost activated carbon. Large scale applications and regeneration of adsorbentscan be focussed extensively in future.

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